Potential gas development impacts on sage grouse nest initiation and movement

Alison G. Lyon and Stanley H. Anderson

Abstract The decline of greater sage grouse (*Centrocercus urophasianus*) over the last 50 years has raised concern over how natural gas development might affect sage grouse populations. We examined the effects of vehicular activity due to gas-well development near Pinedale, Wyoming, on productivity and movements of sage grouse. In 1998–1999, we captured and radiomarked 48 female sage grouse on 6 leks classified as disturbed or undisturbed, based on the presence or absence of natural gas development within 3 km. The mean distance from disturbed leks to selected nest sites was greater (P=0.019 with outliers removed, P= 0.004 with outliers included) than distance moved from undisturbed leks. Nest-initiation rate for hens from disturbed leks was 65%, while hens from undisturbed leks initiated nests 89% (P=0.07) of the time. Nest success at both disturbed and undisturbed leks was 50%. Our results suggest that light traffic disturbance (1–12 vehicles/day) during the breeding season might reduce nest-initiation rates and increase distances moved from leks during nest-site selection. We recommend further investigation concentrating on hen behavior (i.e., distance moved from lek to nest site, breeding behavior, lek attendance), reproductive effort, and nest success in relation to natural gas development as development intensifies.

Key words *Centrocercus urophasianus,* natural gas development, nest initiation, sage grouse, Wyoming

Natural gas and oil development across western North America has been increasing since the 1930s (Bay 1989). One goal of the national policy on energy security is to ensure against energy disruptions by increasing production of domestic sources of natural gas (Bay 1989). According to the American Gas Association, natural gas consumption in the United States is expected to increase by at least 40% by 2015 (PIC Technologies and United States Bureau of Land Management [BLM] 1999).

The possible effects of natural gas development on greater sage grouse (*Centrocercus urophasianus*) populations are largely unknown (Braun 1998). However, both short- and long-term habitat losses may be associated with energy development and mining (Braun 1998). Remington and Braun (1991) reported that sage grouse were displaced by surface coal mining activities but returned to fluctuating predisturbance levels once mining activity ceased. Other studies also have suggested some recovery of populations once mining has ceased (Braun 1986, Remington and Braun 1991). However, there is no evidence that populations attain their predisturbance levels, and population reestablishment could require 20-30 years (Braun 1998).

Although anecdotal evidence has established that gas-oil development can cause sage grouse populations to decline, the reasons for declines are unknown (Braun 1987). The recent discovery of natural gas reserves in northwestern Wyoming has raised concerns over the effects development of these reserves might have on local sage grouse populations. Therefore, we examined distances moved from leks to nests, reproductive effort, nesting habitat, and nest success to test the null hypothesis that vehicular activity due to natural gas development had no effect on sage grouse nest-site selection or productivity.

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Study area

We conducted this study on the Pinedale Mesa in Sublette County, northwestern Wyoming; the town of Pinedale was at the northeast end of the study area. The mesa was bounded by United States Highway 191 to the east, the Green River to the west, and State Highway 351 to the south. The mesa was relatively flat, with an elevation of 2,250 m. A series of draws dissected the southern and northern regions of the area. Total area of the mesa was approximately 30,351 ha, and it was federally owned and managed by BLM. Private land was adjacent to the eastern, southern, and western edges of the area.

The area was dominated by sagebrush (*Artemisia* spp.) and high desert vegetation. Riparian areas and wetlands were associated with the Green and New Fork rivers. Dominant sagebrush species were Wyoming big sagebrush (*A. tridentata wyomingensis*) and basin big sagebrush (*A. t. tridentata*), with some black (*A. nova*), fringed (*A. frigida*), and low (*A. arbuscula*) sagebrush on the study area's northern edges. Principal grasses and forbs found on the mesa were blue wildrye (*Elymus glaucus*), needle and thread grass (*Stipa comata*), Indian ricegrass (*Achnatherum hymenoides*), squirreltail (*Elymus elymoides*), penstemon (*Penstemon* spp.), lupine (*Lupinus* spp.), munroe globemallow (*Sphaeralcea munroana*), blue flax (*Linum perenne*), desert buckwheat (*Eriogonum* spp.), Hood's phlox (*Phlox hoodii*), desert paintbrush (*Castilleja applegatei*), birds beak (*Cordylanthus ramosus*), purple aster (*Machaeranthera canescens*), and milk vetch (*Hedysarum* spp.).

The area believed to contain most of the natural gas has been termed the Pinedale Anticline Project Area (PAPA), which bisected the study area diagonally. On 7 May 1998, BLM's Pinedale Field Manager approved limited exploratory drilling (45 wells) in unexplored areas of Sublette County. This resulted in development of 14 well pads along the anticline crest and 31 well pads outside the anticline area during the study (PIC Technologies and BLM 1999). Main haul roads near the 3 disturbed leks were in place before the exploratory drilling; therefore, development did not impact the study area.

Methods

We used the Wyoming Game and Fish Department lek database to determine which leks currently were active on the mesa study area and their proximity to gas development, and we selected 6 capture leks that we classified as either disturbed or undisturbed. We classified leks as disturbed ($n=3$) if they were within ≤3 km of natural gas development (i.e., well pads or roads). The undisturbed leks ($n=3$) were >3 km from gas development or were ≤3 km from gas development but isolated from potential disturbance factors (i.e., roads and well pads) by topographic features. The 3 disturbed leks were located along a main haul road, where male grouse strutted beside or directly on the road. We captured 48 (1998: $n=24$ from disturbed leks, $n=15$ from undisturbed leks; 1999: $n=8$ from disturbed leks, $n=1$ from undisturbed leks) female sage grouse on and near leks from mid-March through April in 1998 and 1999, by spotlighting and subsequent hoop-netting (Giesen et al. 1982, Wakkinen et al. 1992*b*). We captured fewer hens in 1999 due to use of 2-year radiotransmitters, which enabled us to track the surviving hens in 1999 from the previous year, throughout the 2-year study period. We classified each captured hen by age (Beck et al. 1975) and fitted each with a radiotransmitter secured with a polyvinyl chloride-covered (PVC) wire necklace (Advanced Telemetry Systems Inc., Insanti, Minn.). Transmitters weighed 25 g, had a battery life expectancy of 610 days, and were equipped with motion sensors. We released birds at point of capture after processing. We assumed radiomarked grouse to be a representative sample of the population, with no behavioral differences between marked and unmarked birds.

We located radiomarked grouse at least once per week through the prenesting and nesting periods using hand-held receivers and 3-element Yagi antennas. During prenesting (March–April), sage grouse hens attended a lek, bred, and then retired to the nest area to begin nest initiation. We determined

The Pinedale Mesa study area.

nest locations on foot by circling marked birds until we made visual confirmation. We monitored nests from at least 60 m to minimize human-induced abandonment and predation, and did not revisit nests until monitoring indicated incubation had terminated.

After the hens left the nest area, we examined nests to determine their fate. Nests were considered successful if ≥1 egg hatched, as determined by presence of a detached shell membrane (Wallestad and Pyrah 1974). We monitored unsuccessful hens weekly to evaluate renesting attempts.

At each grouse location, we recorded Universal Transverse Mercator (UTM) of grouse position, radio frequency, sex, date of capture, lek of capture, date of location, general habitat description (e.g., in dense sagebrush stand or riparian corridor), general location description, grouse activity (e.g., on nest, brood rearing), and any disturbance activity. We then entered location data into a spreadsheet format and imported data into ArcView (3.2, Environmental Systems Research Institute Inc., Redlands, Calif.), which we used to track locations throughout the year and measure distance parameters. We obtained vegetative, ownership, hydrologic, and road coverages of the Pinedale Mesa from A. Reeves of PIC Technologies (Denver, Colo.). We projected nest locations (in meters; using UTM 1927) onto vegetative coverage and joined distance tables with corresponding hen attributes in ArcView.

We also recorded vegetative measurements at independent random nest sites chosen by randomly generating UTM coordinates within 3 km of the 6 lek locations. We determined the location of a simulated nest site by selecting a sagebrush bush >35 cm in height closest to the generated independent random points. We evaluated vegetative variables along line transects, centered at the nest site or at a simulated nest site. We randomly chose the direction of the initial transect and oriented the remaining transect perpendicular to the original. Transect length was 15 m (plot area = 707 m^2) for shrub variables and 2.5 m (plot area = 20 m^2) for herbaceous variables.

We utilized the line-intercept method (Canfield 1941) to determine percent live and dead sagebrush and recorded total shrub canopy coverage and height and species of each shrub intercepted. We used height measurements to assess average live sagebrush height and used shrub species composition to determine vegetative community type. We estimated live and dead sagebrush density using a 1-m belt along each 15-m transect.

Radiocollared sage grouse.

We measured herbaceous vegetation variables at the nest (0.5 m) and at 1 m and 2.5 m from the center along each transect. Measurements recorded were grass and residual grass height; percent grass and residual grass; and forb, litter, bare ground, and total herbaceous cover (Daubenmire 1959). We grouped grass species as either new or residual, defining residual grass as any grass standing from the previous growing season.

Statistical analysis

We used separate variance, 2-sample *t*-tests to compare distance moved from lek to nest between hens caught on disturbed versus undisturbed leks (Ott 1988, Minitab Inc. 1994). We analyzed data 2 ways, using the 2-sample *t*-test first; assuming that the longer movements were common, we retained all outliers (data that were >2 standard deviations) in the analysis. In the second analysis, we considered data >2 standard deviations from the mean as outliers and did not include them in the statistical analysis. We completed the second analysis recognizing >2 standard deviations as a limitation.

We used separate variance, 2-sample *t*-tests to compare vegetative measurements between random nest plots ≤3 km from a disturbed lek versus random nest plots ≤3 km from an undisturbed lek. We conducted a Bonferroni adjustment to control experiment-wise error rate at $\alpha = 0.20$ to designate significant values for each variable. Alpha was divided by the number of variables ($n = 15$) in the data set and further separated by distributing the alpha based on the variables *a priori* perceived importance and internal correlation. This resulted in critical alpha values ranging between 0.0095 and 0.0250. We set the critical alpha at 0.20 to guard against Type II errors (Dowdy and Wearden 1991).

Table 1. Nesting summary by year, age, and disturbed or undisturbed capture leks of marked female sage grouse on the Pinedale Mesa, Wyoming, 1998–99.

Year	Lek type	*n*	No. mortality	No. initiated (%)	No. successful (%)
1998	Disturbed	24	0	17 (71%)	9 (53%)
	Undisturbed	15	2	11 (85%)	5 (45%)
1999	Disturbed	25	0	15 (60%)	7 (46%)
	Undisturbed	13	1	11 (92%)	6 (55%)
1998–99 Sub-total:					
	Disturbed	49	0	32 (65%)	16 (50%)
	Undisturbed	28	3	22 (89%)	11 (50%)
Total:		77	3	54 (73%)	27 (50%)
Successive year nests (nested both 1998 and 1999):					
	Disturbed	18	0	10 (56%)	
	Undisturbed	11	0	9 (82%)	

We took this conservative approach because sage grouse are considered a sensitive keystone species of sagebrush ecosystems and likely are a good indicator of subtle differences in the data. We used a chi-square test to determine possible difference in proportion of hens that initiated nests versus overall number of hens between disturbed and undisturbed leks.

Results

Mean hen-movement distance from disturbed leks to selected nest sites was greater ($P \leq 0.05$) than movements from undisturbed leks. Hens breeding and initiating nests on disturbed ($n=32$) and undisturbed ($n=22$) leks moved 4,116 m and 2,090 m, respectively ($P=0.019$, with 7 outliers removed) and 12,443 m and 2,090 m ($P=0.004$, outliers included) between leks of capture and selected nest sites. Twenty-six percent of hens captured on disturbed leks nested within 3 km of the lek of capture, compared to 91% of hens captured on undisturbed leks.

The nest-initiation rate for hens from disturbed leks was 65%, while hens from undisturbed leks initiated nests 89% of the time ($\chi^2_1=3.2723, P=0.070$, Table 1). Ten of 18 hens (56%) marked on disturbed leks initiated nests in consecutive years, while 9 of 11 hens (82%) marked on undisturbed leks initiated nests in consecutive years (Table 1). No relationship appeared to exist between previous year's nest fate and nest initiation the following year. Also, adult initiation (71%) versus yearling initiation (69%) rates were approximately the same and should not have influenced initiation rates. Hatching success between hens from disturbed and undisturbed leks did not differ (Table 1), and the probability of a successful hatch did appear to be associated with distances traveled from lek to nest. Nest-vegetation analysis demonstrated no significant ($\alpha=0.2$) differences between random nest plots within 3 km of disturbed leks versus undisturbed leks.

Discussion

Wallestad and Pyrah (1974) found that 68% of undisturbed hens nested an average of 2.5 km from the lek where captured in central Montana. Wakkinen et al. (1992*a*) reported that 55% of sage grouse nests in southeastern Idaho were ≤3 km from the lek of capture. The authors discussed cattle grazing from April to July as a possible disturbance. The BLM does not allow natural gas development within 3.12 km of a lek on the PAPA from February through July (period of nesting and early brood-rearing), based on the 1977 sage grouse management guidelines (Braun et al. 1977). These guidelines were designed in part to restrict potential disturbances to breeding sage grouse from anthropogenic activities associated with natural-resource extraction, such as construction, earth displacement, and foot or vehicular traffic (Braun et al. 1977). On the Pinedale Mesa, potential disturbances associated with natural gas development were restricted to vehicular traffic on the pre-existing main haul road. All males from the 3 disturbed leks in our study strutted either on or within 15 m of this road. However, the mean number of vehicles using the mesa road in a 24-hour period during spring and summer of 1998 and 1999 was ≤12 (Ingelfinger 2001).

Hens we captured on disturbed leks demonstrated greater movements from capture lek to nest than hens from undisturbed leks. Hens from disturbed leks nested approximately twice as far from capture leks as did hens from undisturbed leks. Our random nest-vegetation analysis indicated no significant differences in nesting habitat between disturbed and undisturbed areas, suggesting that nest habitat was not influencing sage grouse hen movements. Therefore, we believe hens from disturbed leks were nesting farther from the lek due to light road traffic (1–12 vehicles per day) during breeding.

Reproductive effort (nest initiation) of sage grouse can vary from 68-93% (Connelly et al. 1993, Schroeder 1997). Coggins (1998) noted a 99% nest-initiation rate over 3 years in Oregon. Studies of follicular development in sage grouse hens indicated that 91- 98% were bred annually (Braun 1979). We found that hens from disturbed leks displayed a lower nest initiation rate than those from undisturbed leks (Table 1). Nest-habitat factors did not appear to have a role in selection differences; therefore, we hypothesize that the difference in initiation rates between disturbed and undisturbed hens was caused by disturbance—specifically, road traffic near the lek during the breeding season. Connelly et al. (1993) demonstrated that up to 45% of yearling and 22% of adult female sage grouse might not nest each year. However, we did not observe any initiation differences between age classes.

Finally, even though nest initiation between disturbed and undisturbed hens was not statistically significant, we believe lower initiation rates for disturbed hens were biologically significant and could result in lower overall sage grouse productivity. We assumed that 100% of marked hens were bred because they were captured while attending the leks. Disturbed hens had lower initiation rates than undisturbed hens, while nest success between the 2 areas was the same (50%). Therefore, it appeared that once a hen initiated a nest, hatching success was dictated by the selected area and not influenced by road traffic or disturbance. If disturbed hen nest success (n =16) was compared to potential disturbed nesting hens (n=49), productivity was 33%, while undisturbed hens (n=25 potential, n=11 successful) demonstrated 44% productivity. Braun (1986) reported that upgrade of haul roads associated with surface coal mining in North Park, Colorado, resulted in a lek (50 m from a road) becoming inactive and an 83% reduction in strutting males on another lek (500 m from a road) within 3 years of the upgrade. Braun (1986) attributed recorded declines in number of males on leks to absence of yearling-male recruitment, suggesting that productivity was low the previous year or juvenile males were using different lek sites. Due to initiation results, we hypothesize that even minimal disturbance during initiation could result in lower nest initiation and therefore lower productivity. Few juvenile males on leks may indicate reduced productivity resulting from low nest-initiation rates, not different lek-site selection.

Gas wells on the Pinedale Mesa.

Management implications

The upgrade of coal-hauling roads (and subsequent increase in traffic volumes) in Colorado resulted in declined male lek attendance (Braun 1986). Once a gas well has been drilled, most of the disturbance within a natural gas field is traffic-related. Our study suggested that traffic disturbance of 1-12 vehicles per day during the breeding season might reduce nest-initiation rates and increase distances moved from leks during nest-site selection. The BLM currently restricts road activities on the Pinedale Mesa from midnight-9 am during the sage grouse breeding season (K. J. Andrews, Pinedale BLM, personal communication). However, even with these restrictions, hens may have been affected by road disturbance, suggesting that further traffic restrictions should be considered.

Natural gas development was in the preliminary stages during our study. As gas development continues, new impacts on sage grouse populations could occur. Consequently, we recommend further investigation of hen response during the breeding season to increasing levels of natural gas development. We also suggest that studies be initiated to examine current BLM regulations restricting any year-round surface disturbance within 0.4 km of a lek and any surface disturbance during the breeding and nesting season within 3.12 km of the lek (K. J. Andrews, Pinedale BLM, personal communication).

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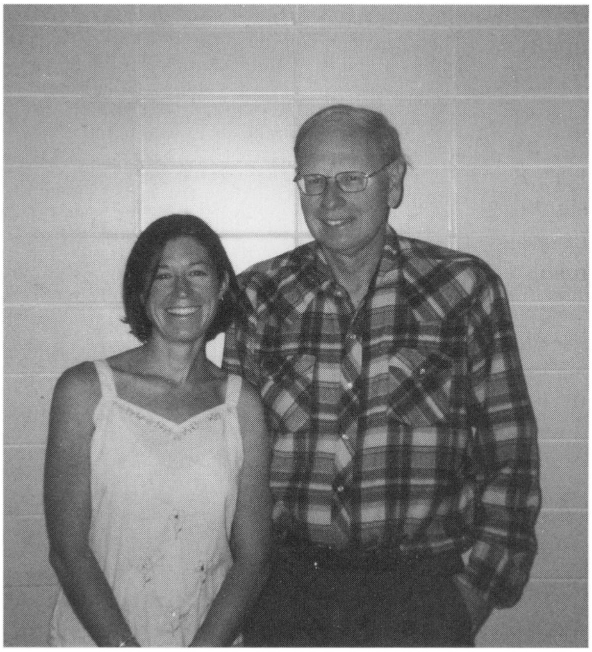

Dr. Stanley Anderson (right) is the leader of the Wyoming Cooperative Fish and Wildlife Research Unit. He has conducted extensive studies on wildlife throughout the world. Dr. Anderson received his Ph.D. from Oregon State, taught at Kenyon College, worked at the Patuxent Research Center, and has been at the University of Wyoming for 23 years. ***Alison Lyon*** (left) graduated with a B.S. in wildlife management from the University of West Virginia in 1994 and obtained her M.S. in zoology and physiology in 2000 from the University of Wyoming. Upon completing her Master's, Alison went to work for the Wyoming Cooperative Fish and Wildlife Research Unit, developing and executing a research plan examining the potential effects of natural gas development on sage-grouse populations. Currently she is the state conservation coordinator for Audubon Wyoming.

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